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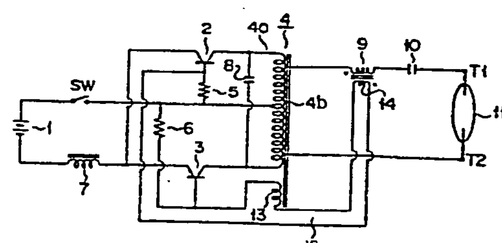
(54) Transistor inverter device.

(57) Under control by a switching control circuit (12), a DC current fed from a DC power source (1) is fed alternately into switching transistors (2, 3) through an input winding (4a) of an output transformer (4). A composite signal of a fundamental wave component and a third harmonic component supplied from an output winding (4b) of the output transformer (4) to a high intensity discharge lamp (11) is detected by a winding (13), and a difference signal, i.e. a fundamental wave signal, between the composite signal and the third harmonic component detected by a winding (14) is applied as a switching control signal from the control circuit (12) to the bases of the switching transistors (2, 3).

F I G. 2



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Transistor inverter device

The present invention relates to a transistor inverter device in which an AC output signal obtained by switch controlling a pair of transistors so as to render the transistors alternately conductive is led out through a plurality of resonance circuits.

A waveform of an output signal from a normal transistor inverter device is sinusoidal, but a waveform as shown in Fig. 1(a) is desirable for the waveform of an output signal from a transistor inverter device used in an operating device for a high intensity discharge lamp such as mercury lamps, high-pressure sodium lamps and metal halide lamps, for example. The waveform shown in Fig. 1(a) is formed by superposing to a fundamental wave at a period T a third higher harmonic wave at a 1/3 period of that of the fundamental wave.

A base voltage waveform of one of a pair of the transistors constituting the inverter when the inverter produces an output signal with the waveform as shown in Fig. 1(a) is similar to and in synchronism with a waveform of the output signal from the inverter, as shown in Fig. 1(b). The actual base voltage waveform is slightly different from that of the output signal due to the leakage component of an inverter transformer. Under this condition, the transistor inverter device accordingly keeps a stable oscillation at the period T.

As is well known in the art the internal impedance of the high intensity discharge lamp immediately after the start of its operation is zero, and increases up to its rated value as the pressure of the vaporized gas increases. Since the phase and amplitude of the oscillation output from an oscillation circuit are influenced by the internal impedance of the high intensity discharge lamp, the output waveform of the oscillation circuit varies with the continuous change of the impedance from zero to the rated value. At a time of starting of a mercury lamp of 250-watt, for instance, the internal impedance varies from zero to 60 ohms. The intermediate waveform at the lamp impedance of 0 to 20 ohms, for example, is as shown in Fig. 1(d). When the impedance becomes to 60 ohms, the output waveform is as shown in Fig. 1(a). Further, an abnormal discharging phenomenon is often observed at the time of starting immediately after power on of the conventional transistor inverter due to the fluctuation of the lamp impedance. At this time, the impedance changes in at random fashion in such a manner 0 to 20 ohms which is followed by ∞.

Thus, when the output waveform of the transistor inverter device dies down to a level near a zero level at the mid portion of the half period (T/2), as shown in Fig. 1(d), the base voltage waveform contains a period falling beyond the zero level during the half period (T/2), as shown in Fig. 1(e), because the electromagnetic coupling between a main winding and a base winding for the third harmonic wave is stronger than that for the fundamental wave. When the base voltage as shown in Fig. 1(e) is applied to the transistor, the collector current contains a zero level portion during the half-period (T/2), as shown in Fig. 1(f). In other words, an abnormal oscillation attendant with at random change of oscillation frequency takes place. Incidentally, the waveform shown in Fig. 1(f) is the one of the collector current of one of the pair of the transistors. Regarding to the collector current of the other transistor, the waveform is exactly the same as that of the counterpart except a difference of the phase of 180°.

Accordingly, an object of the present invention is to provide a transistor inverter device which produces an oscillating output signal containing higher harmonics through a stable operation.

To achieve the above object, there is provided a transistor inverter device comprising: a DC power source for supplying a DC current; at least one switching transistor and a first winding connected in series with both ends of the DC power source; a fundamental wave resonance circuit adopted to receive an output current of the switching transistor to resonate at a fundamental frequency corresponding to a switching period of the switching transistor; at least one higher harmonic resonance circuit resonating at a frequency of at least one of the higher harmonic components with respect to the fundamental wave resonance frequency; means for supplying a composite signal of the fundamental wave component and the higher harmonic component to a load; and a control circuit which forms a difference signal between the composite component and the higher harmonic component, and controls the switching operation of the switching transistor by the difference signal.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows voltage waveforms useful in explaining the operation of a prior transistor inverter;

Fig. 2 shows a circuit diagram of an embodiment of a transistor inverter device according to the present invention;

Fig. 3 is an equivalent circuit of a leading portion of the circuit shown in Fig. 2;

Fig. 4 shows voltage waveforms with the aid in explaining the operation of the inverter device shown in Figs. 2 and 3; and

Fig. 5 is a circuit diagram of another embodiment of a transistor inverter device according to the present invention.

Referring to Fig. 2, there is shown a circuit arrangement of an embodiment of a transistor inverter according to the present invention applied for operating a high intensity discharge lamp. In the figure, a DC power source 1 may be a battery, a rectifier for providing a rectified but not smoothed DC output, or a rectifier for providing a rectified and smoothed DC output. Transistors 2 and 3 serve to switch the current fed from the DC power source 1. In the present embodiment, the transistors 2, 3 are coupled in parallel with an input winding 4a of an output transformer 4. It should be understood, however, that the present invention is not limited to this connection arrangement, but applicable to any known arrangements. Resistors 5 and 6 are base resistors through which base currents are fed to the transistors 2 and 3. An inductor 7 connected between the source 1 and transistors 2 and 3 serves to restrict a high frequency component of the input current fed from the DC power source 1. A capacitor 8 is connected across the input winding 4a of the output transformer 4 and cooperates with the winding 4a to form a starting resonance circuit A to be given referring to in Fig. 3. An inductor 9 connected in series to the output winding 14b through a capacitor 10 and the discharge lamp 11 is used, together with the capacitor 8, for forming a second resonance circuit C, and the capacitor 10 cooperates with the output winding 14b to form a first resonance circuit B, as will be described referring to Fig. 3. The inductor 9 and capacitor 10, connected in series, serve to restrict a lamp current to a high intensity discharge lamp 11 such as a mercury lamp. A switch control circuit 12 for switching the transistors 2 and 3 produces a different signal between a composite signal of output signals from the first and second resonance circuits B and C and the output signal from the second resonance circuit C and supplies the difference signal to the bases of the transistors 2 and 3 thereby switching the transistors 2 and 3. As shown, the control circuit 12 includes a first winding 13 electromagnetically coupled with the output transformer 4 and a second winding 14 electromagnetically coupled with the inductor 9.

The first and second resonance circuits B and C will be described in detail referring to Fig. 3. Fig. 3 illustrates an equivalent circuit of the leading portion of the circuit shown in Fig. 2. In the figure, like numerals designate like portions in Fig. 2. The first resonance circuit B is comprised of the output winding 4b, the capacitor 10 with the current restricting function and the discharge lamp load 11, and resonates at 30 kHz as the fundamental wave component. The second resonance circuit C is comprised of the capacitor 8 connected across the input winding 4a, the inductor 9 and the discharge lamp 11. The second resonance circuit C resonates at 90 kHz (third harmonic wave), for example, which is three times the fundamental wave frequency. The resonance frequency may be properly selected to some degree by changing the circuit constants in the resonance circuit, if necessary. In the circuit arrangement, when the lamp impedance is low and the output waveform is as shown in Fig. 4(a), a voltage as shown in Fig. 4(b) is induced in the first winding 13 electromagnetically coupled with the output transformer 4. In this case the inverter is operating in a mixed oscillation mode wherein a fundamental and harmonic waves are involved. A third harmonic wave voltage as shown in Fig. 4(c) is induced in the second winding 14 electromagnetically coupled with the inductor 9. Thus, the voltage of Fig. 4(c) does not include a fundamental wave component. When the second winding 14 is coupled with the inductor 9 oppositely in the winding direction, as shown in the figure, the output signal from the second winding 14 is subtracted from the output signal of the first winding 13, so that the fundamental wave component shown in Fig. 4(d) is left. The difference signal with the fundamental waveform does not have a zero-cross period and is well used for switching the transistors 2 and 3. A closed circuit as indicated by an arrow A is the starting resonance circuit resonating at 40 kHz, for example, used for starting the operation of the load 11 in a no-load state. This starting resonance circuit is not essential to the present invention.

The operation of the above-mentioned embodiment of Figs. 2 and 3 will be given hereinafter. Upon turning on a power switch SW, either of the transistors 2 and 3 is turned on. Then, current flows through a route; a positive terminal of the DC power source 1 - part of input winding 4a - transistor 2 or 3 in an ON state - inductor 7 - negative terminal of the DC power source 1. In this way, the voltage is applied to the input winding 4a, so that the input winding 4a and the capacitor 8 parallel-resonates, as indicated by the arrow A. As the result of the parallel resonance, a voltage is induced also in the first winding 13. When the polarity of the parallel resonance is inverted, the voltage induced in the first winding 13 is inverted. Then, the transistor in an ON state is turned off, while the transistor in an OFF state is turned on. Accordingly, the resonance voltage with the opposite polarity to the previous voltage is produced. Similarly, the polarity of the resonance voltage is then inverted, so that the transistors are switched. Subsequently, the just-mentioned operation is repeated. The resonance voltage thus produced is applied through the inductor 9 and the capacitor 10 to the discharge lamp 11 which in turn is operated.

After the discharge lamp 11 as the load is operated, the first and second resonance circuits B and C in Fig. 3 becomes active. At this time, the first resonance circuit B resonates at the frequency of the fundamental wave component, 30 kHz, to produce the voltage of the fundamental frequency. The second resonance circuit C resonates at the treble frequency of that of the fundamental wave component, 90 kHz, to produce the voltage shown in Fig. 4(c).

Accordingly, the composite voltage (Fig. 4(a)) of the fundamental wave component and the treble frequency component is applied to the load 11. In the control circuit 12, the composite voltage is induced in the first winding 13 and the third harmonic voltage is induced in the second winding 14. The difference voltage between those voltages, i.e. the voltage of the fundamental wave component, switch-controls the transistors 2 and 3. Therefore, a stable switching of the transistors is ensured free from the adverse effects by the voltage as shown in Fig. 4(c) or 4(d). Further, even if the load 11 becomes in an abnormal state, the oscillation of the transistor inverter is kept stably. ON the other hand, if those transistors are switched by using the voltage as shown in Fig. 4(b), it is apparent that the oscillation in the circuit shown in Fig. 1 is brought to an abnormal state. Further, since the discharge lamp 11 is impressed with the fundamental wave component and the treble frequency component, it is free from an unstable operation called an acoustic resonance phenomenon.

Turning now to Fig. 5, there is shown another embodiment of a transistor inverter device according to the present invention. In Fig. 5, like reference numerals are used to designate like portions in Fig. 2. In the present embodiment, the output transformer 4' is of the insulating type. A first resonance circuit B' is comprised of a capacitor 8 connected in parallel with an input winding 4a' of an output transformer 4', an inductor 15 with a current limiting function, and a load 11. The second resonance circuit C' is formed of a capacitor 16 connected in parallel with an output winding 4b' of the output transformer 4', an inductor 17, an inductor 15 with the current limiting function and the load 11. A voltage as shown in Fig. 4(a) is produced in the transformer 4' by properly selecting circuit constants. A switching control circuit 12' includes a first winding 18 electromagnetically coupled with the output transformer 4' and a second winding 19 electromagnetically coupled with the inductor 17. As a matter of fact, the present embodiment can stably keep the oscillation of the transistor inverter, as in the first embodiment shown in Fig. 2.

It should be understood that the present invention is not limited to the above-mentioned specific embodiments. For example, the high intensity discharge lamp as the load may be substituted by any other suitable load. Another resonance circuit or circuits, in addition to the first and second resonance circuits, may be used in accordance with a waveform of the output signal from the inverter. In this case, the control circuit must subtract the output component derived from the additional resonance circuit from the composite signal of the output signals derived from the resonance circuits. Further, the frequencies of the fundamental component and the higher harmonic component are not limited to the above-mentioned ones.

As described above, the transistor inverter device has a first resonance circuit resonating at the fundamental frequency component and a second resonance circuit resonating at the frequency of the higher harmonic component. A signal formed by subtracting the high frequency component from the composite signal of the output signals produced from the respective resonance circuits is used for the switching control of the switching transistors. Therefore, there is eliminated an abnormal oscillation due to the higher harmonic component and the composite signal of the fundamental wave component and the higher harmonic component. As a consequence, the transistor inverter provided by the present invention can keep a stable oscillation.

Claims:

1. A transistor inverter device comprising: a DC power source (1) for supplying a DC current; at least one switching transistor (2, 3) and a first winding (4a) connected in series with both ends of said DC power source (1); a fundamental wave resonance circuit (B, B') adopted to receive an output current of the switching transistor to resonate at a fundamental frequency corresponding to a switching period of said switching transistor (2, 3); at least one higher harmonic resonance circuit (C, C') resonating at a frequency of at least one of the higher harmonic components with respect to the fundamental wave resonance frequency; means (T1, T2) for supplying a composite signal of the fundamental wave component and the higher harmonic component to a load (11); and a control circuit (12, 12') which forms a difference signal between said composite component and said higher harmonic component, and controls the switching operation of said switching transistor (2, 3) by said difference signal.

2. A transistor inverter device according to claim 1, wherein said control circuit (12, 12') includes a second winding (13, 18) for picking up said composite signal and a third winding (14, 19) for picking up said higher harmonic component.

3. A transistor inverter device according to claim 1 or 2, wherein said load (11) is a high intensity discharge lamp.

4. A transistor inverter device according to claim 1, 2 or 3, wherein said fundamental resonance circuit (B) includes an output winding (4b) overlapping with said first winding (4a), and a first capacitor (10)

connected in series to said load (11) between both ends of said output winding (4b), and said higher harmonic resonance circuit (C) includes a capacitor (8) connected between both ends of said first winding (4a), an inductor (9) connected in series with said first capacitor (10) between both ends of said output winding (4b), and a load (11).

5. A transistor inverter device according to claim 1, wherein said higher harmonic component is a third higher harmonic wave.

6. A transistor inverter device according to claim 4, wherein said first winding (4a) and said capacitor (8) from a parallel resonance circuit serving as a starting resonance circuit when said load (11) starts its operation.

7. A transistor inverter device according to claim 1, 2 or 3, wherein said fundamental resonance circuit (B') includes an input winding (4a') of an output transformer (4'), a capacitor (8) coupled in parallel with said input winding (4a'), an inductor (15') connected in series with an output winding (4b') of said output transformer (4'), and a load (11), and said higher harmonic resonance circuit (C') includes a series circuit of a capacitor (16) connected in parallel with said output winding (4b') of said output transformer (4') and an inductor (17), said inductor (15') and a load (11).

FIG. 1

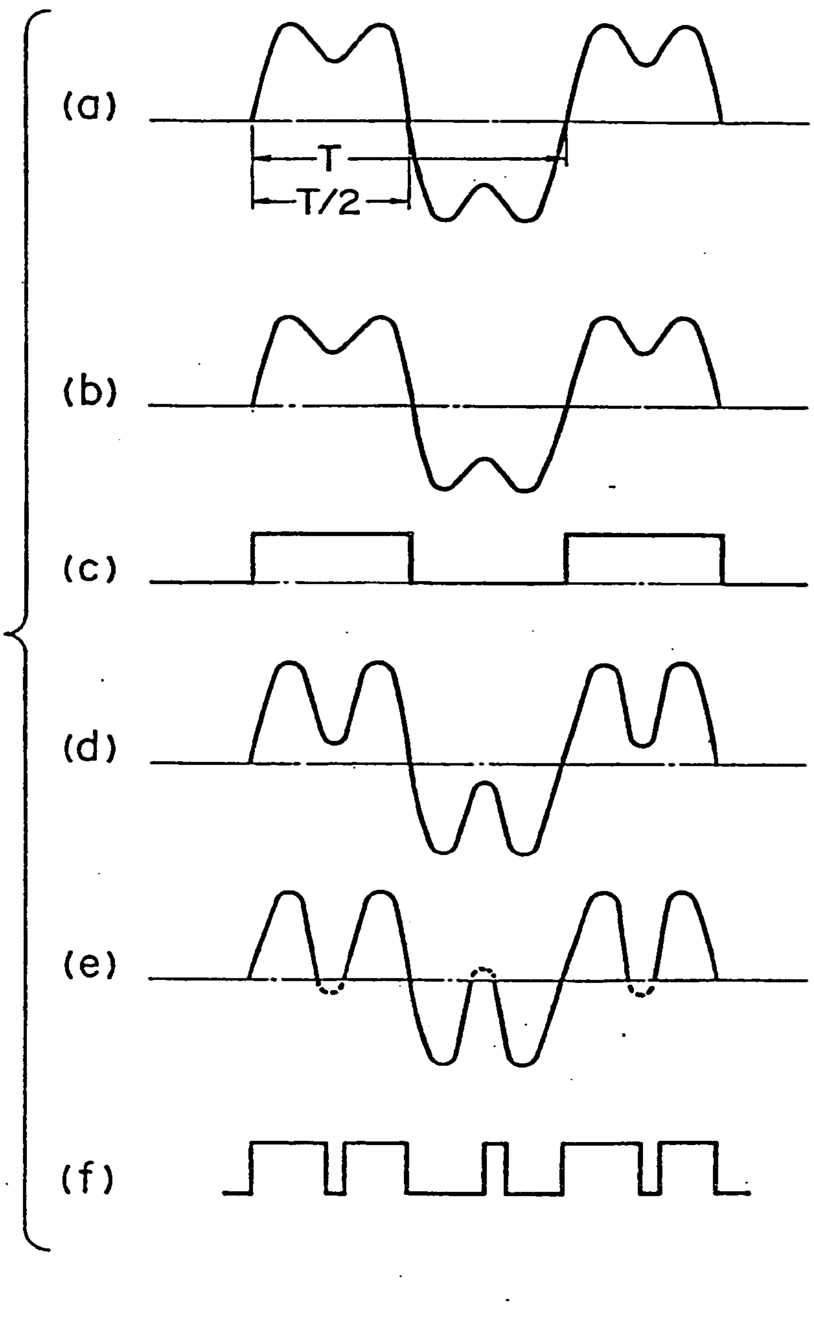


FIG. 2

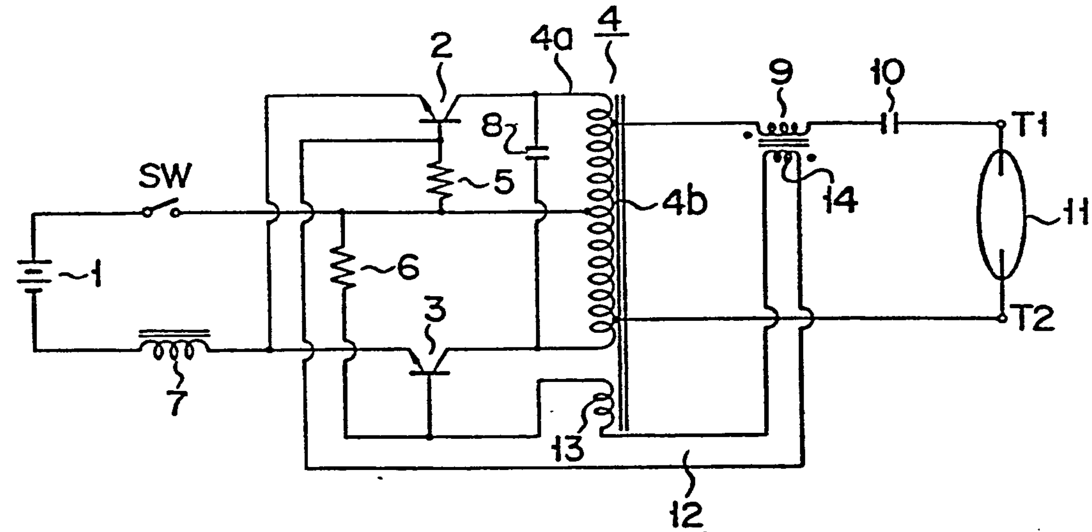
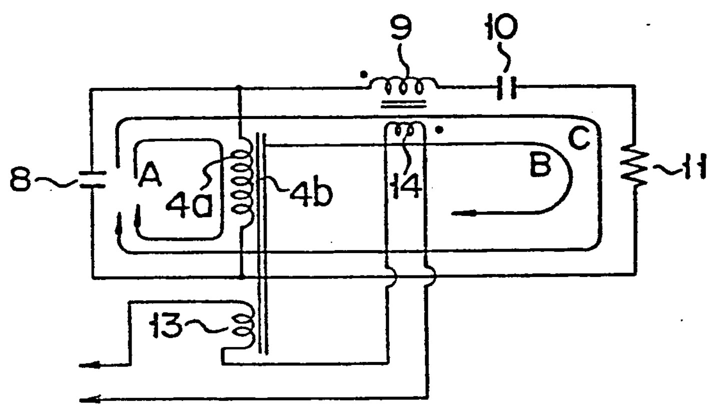
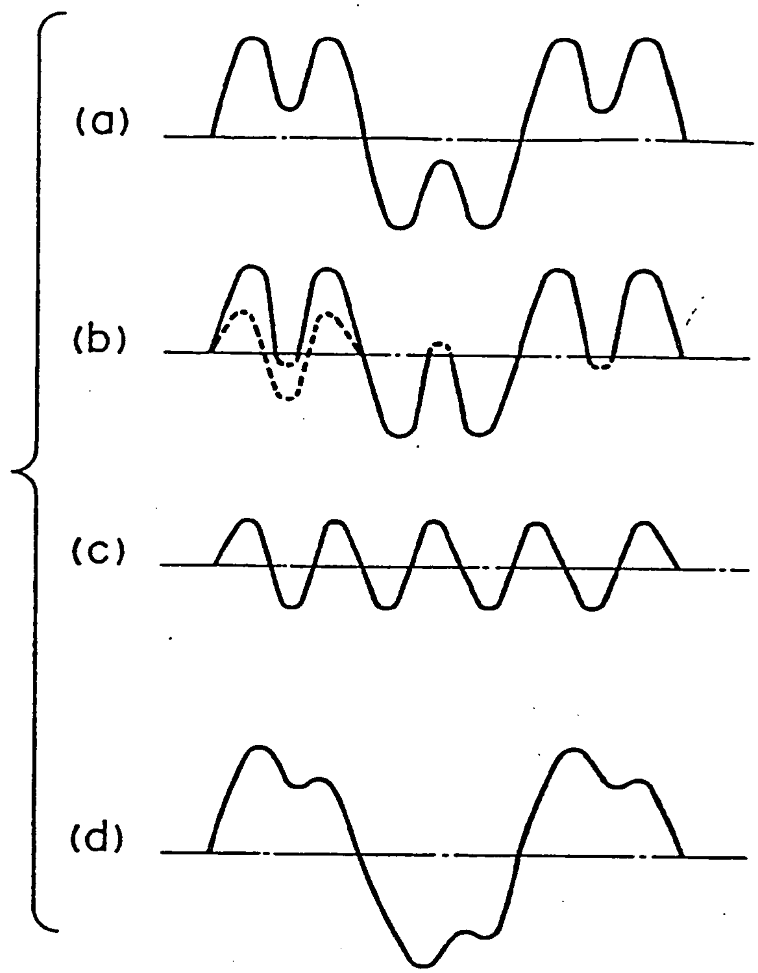


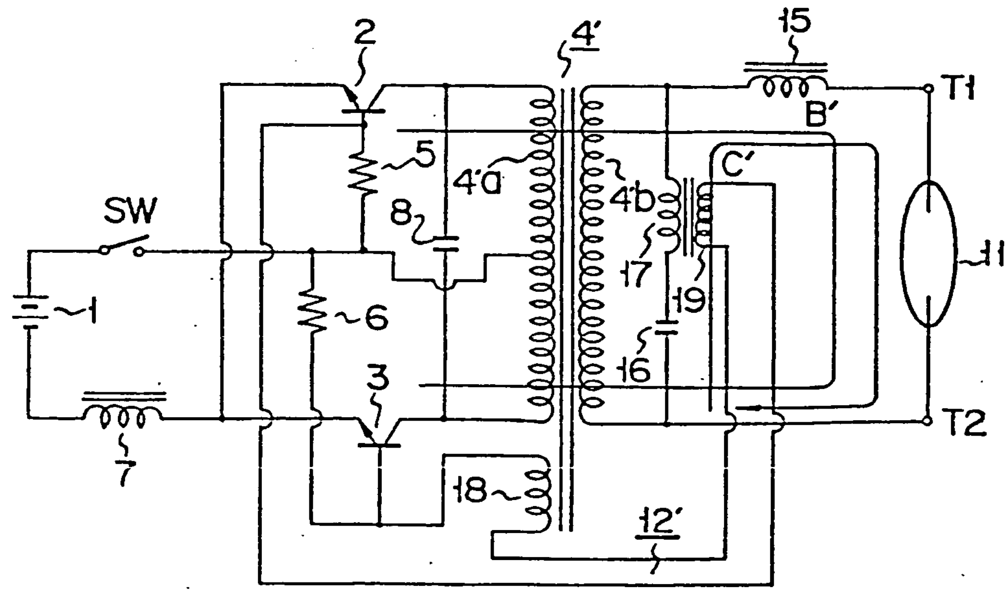
FIG. 3



F I G. 4



F I G. 5



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EUROPEAN SEARCH REPORT

0078864

Application number

EP 81 10 9627

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	GB-A-2 074 801 (TOSHIBA) *Page 3, line 13 to page 4, line 30; figure 5*	1-7	H 05 B 41/29
	-----		**TECHNICAL FIELDS SEARCHED (Int. Cl. 3)**
			H 04 B 41/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22-07-1982	DUCHEYNE R.C.L.

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